STRUCTURAL AND FOUNDATION DESIGN OF A SHORT-SPAN RURAL BRIDGE AT BRGY. POBLACION, NORZAGARAY, BULACAN

A Research Paper

Presented to the

Faculty of the Civil Engineering Division

La Concepcion College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science in Civil Engineering

Major in Construction Engineering and Management

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2025

RECOMMENDATION

This is to certify that this research entitled "STRUCTURAL AND FOUNDATION DESIGN OF A SHORT-SPAN RURAL BRIDGE AT BRGY. POBLACION, NORZAGARAY, BULACAN," prepared and submitted by John David V. Almadin, Cielo Marie Pearl Guieb, and Sharee Maine Mostrales in partial fulfillment of requirements for the degree Bachelor of Science in Civil Engineering, is hereby recommended for Pre-Oral Examination.

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Furthermore, we declare that the intellectual content of this thesis is the product of our work, although we have received assistance from others on the manner of organization, presentation, language, and style.

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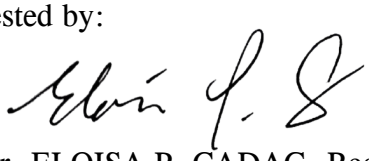

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CHAPTER 1

THE PROBLEM AND ITS BACKGROUND

This chapter presents the introduction, background of the study, theoretical framework, conceptual framework, statement of the problem, objectives of the study, hypothesis, significance of the study, scope and limitations, and definition of terms.

Introduction

A well-structured bridge is crucial in rural areas, as it serves as the primary route for daily transportation and economic activities, connecting communities to nearby town centers. However, it must be designed with adequate strength to withstand both expected and unexpected loads, such as light and heavy vehicles, flash floods, and rising water levels. The bridge in Brgy. Poblacion, Norzagaray, Bulacan, collapsed last July 2025 due to weak foundations and heavy rainfall, affecting the livelihoods of residents and making it difficult to access the town proper. The area was merely backfilled with soil as a temporary solution, but it failed to ensure structural stability. Residents now have to take alternative routes, which is a hassle for them because they have to use more fuel and take longer routes to commute. Meanwhile, the primary design objective of a bridge is safety, and such a temporary solution does not guarantee compliance with structural standards.

Given these challenges, this research focuses on the structural and foundation design of a short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan. The study aims to develop a design that ensures both structural and foundation stability in accordance with DPWH standards. Brgy. Poblacion's issue needs to be thoroughly investigated to restore the community's access to economic opportunities as well as to provide a safe and long-lasting solution. More than just an engineering project, the proposed bridge emphasizes how rural infrastructure supports livelihoods, promotes local development, and ensures resilience against both natural and man-made hazards.

Background of the Study

Bridges are an essential part of rural infrastructure because they allow people to travel safely and directly between communities. For residents in rural areas, short-span bridges are significant since they serve as the central passage for work, education, health services, and local trade. When a bridge becomes unsafe or impassable, daily life is significantly affected. Residents are often forced to take longer routes, which increases fuel consumption, travel time, and overall inconvenience. Studies have shown that good connectivity is critical for improving the quality of life in rural places. According to the Asian Development Bank (2022), rural infrastructure directly influences economic productivity, while Kaiser and Barstow (2022) emphasize that rural transport systems, including roads and

bridges, are essential for health, education, governance, and agriculture. Thus, strengthening rural bridge infrastructure is vital not only for mobility but also for advancing socioeconomic growth.

In the Philippines, the vulnerability of bridges is closely influenced by the country's climate conditions, as frequent typhoons, heavy rainfall, and flooding expose structures in low-lying areas to rapid deterioration and failure. The Department of Public Works and Highways (2022) emphasizes the importance of maintaining road and bridge infrastructure using standard guidelines, stressing that scour and erosion resulting from fast-moving water are among the most severe risks in flood-prone provinces like Bulacan. On a global scale, scour has been identified as the leading cause of bridge collapse because it gradually erodes soil around foundations, decreasing stability and causing serious hazards to travelers (Kazemian et al., 2023). Traditional scour monitoring methods are often limited by underwater installation difficulties and data inaccuracies, although recent vibration-based techniques offer more reliable alternatives. Pizarro et al. (2020) further emphasize that without proper countermeasures, scour and foundation instability will continue to threaten bridge reliability worldwide, underscoring the need for improved monitoring, modeling, and design practices.

This issue is evident in Brgy. Poblacion, Norzagaray, Bulacan, where a short-span rural bridge has been repeatedly damaged by flooding and has progressively weakened despite temporary repairs. Soil has been laid over the

damaged portion to restore limited access, but this measure remains unstable and prone to collapse during heavy rains, putting residents at continued risk. Garcia et al. (2024) reported similar conditions in the Philippines, where many bridges, particularly those traversing geologically vulnerable areas, have either reached or exceeded their design life, resulting in structural deterioration and frequent maintenance demands. Their study highlights that makeshift repairs, while immediately practical, do not provide long-term stability and often lead to greater safety risks. These conditions not only endanger communities but also strain the limited resources of local governments responsible for repair and rehabilitation.

The consequences of an unsafe bridge extend far beyond daily inconvenience, as residents in Brgy. Poblacion experience longer travel times, higher fuel expenses, and increased transportation difficulties due to detours. These disruptions directly affect students, whose school attendance and academic performance suffer from delays, and workers, who lose productivity and income opportunities because of added travel burdens. Callanta and Moreno (2024) found that inadequate rural transport infrastructure limits household welfare by restricting access to markets, healthcare, and employment opportunities, thereby constraining economic growth in affected communities. Similarly, when bridges and roads are unsafe, emergency services face delays in reaching residents during floods or other disasters, intensifying the risks for vulnerable populations.

Temporary or makeshift repairs to bridges and other critical infrastructure often fail to ensure long-term safety and may weaken community preparedness for disasters. According to De Silva et al. (2022), integrating more reliable engineering solutions can improve adaptability by lowering exposure and vulnerability to natural disasters, particularly when translated from policy frameworks into local planning. At the same time, strong transport systems are vital for maintaining economic stability and community functionality during crises. The International Transport Forum of the OECD (2024) highlights that assessing vulnerabilities and applying effective mitigation measures are central to maintaining continuity of transport services amid climate-related and other systemic disruptions. Collectively, these perspectives underscore the importance of shifting from temporary interventions toward durable and safe engineering solutions for rural infrastructure.

Given these circumstances, there is a pressing need to develop a structurally resilient bridge for Brgy. Poblacion, Norzagaray, Bulacan. This study aims to propose a design that reinforces the structural foundation, integrates effective drainage systems, and ensures long-term durability and safety. By prioritizing functionality and reliability, the project seeks to safeguard mobility and enhance the welfare of the community. Furthermore, the design may serve as a reference for other rural areas in the Philippines facing similar vulnerabilities, contributing to the broader goal of ensuring dependable local infrastructure in the years ahead.

Location of the Study

The study is situated in Brgy. Poblacion, Norzagaray, Bulacan, a central area within the municipality that serves as a passageway for residents traveling between nearby barangays and the town proper. The existing bridge site lies along a local road that provides access for pedestrians and light vehicles. Due to its proximity to residential zones and frequent exposure to rainfall and flooding, the site presents relevant conditions for a structural and foundation design study.

Figure 1. *Vicinity Map of the Proposed Short-Span Rural Bridge in Brgy. Poblacion, Norzagaray, Bulacan*

The location provides a realistic basis for evaluating bridge design requirements under rural conditions. Its existing structural challenges, combined with its significance to local mobility, make it a suitable site for developing a design that prioritizes safety, resilience, and long-term functionality.

Theoretical Framework

This study is grounded on established theories that provide the foundation for its structural and geotechnical aspects. These theories guide the formulation of research questions, support the design approach, and ensure that the proposed bridge is structurally sound and environmentally resilient.

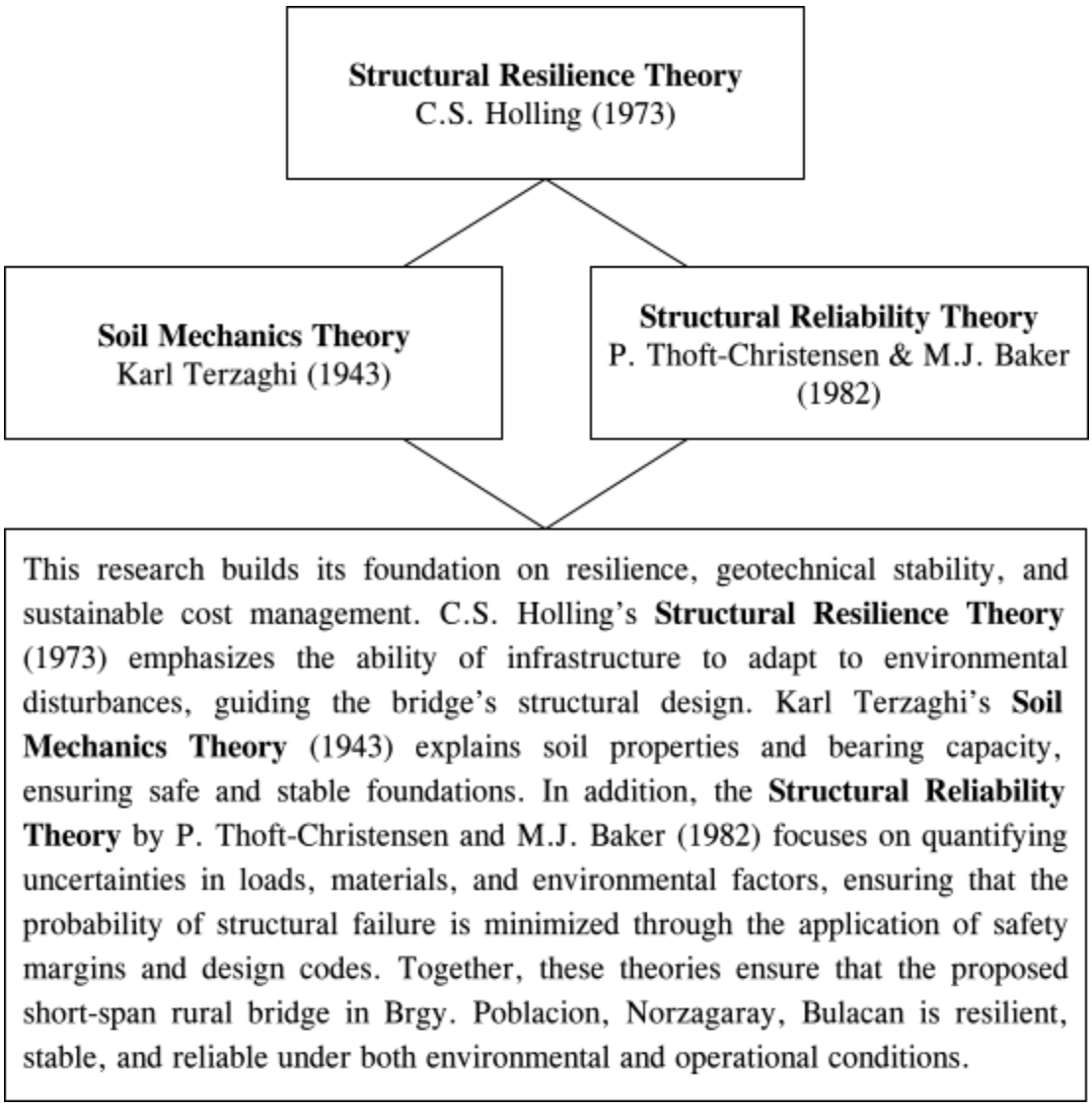
Structural Resilience Theory
C.S. Holling (1973)
Soil Mechanics Theory
Karl Terzaghi (1943)
Structural Reliability Theory
P. Thoft-Christensen & M.J. Baker (1982)
This research builds its foundation on resilience, geotechnical stability, and sustainable cost management. C.S. Holling's Structural Resilience Theory (1973) emphasizes the ability of infrastructure to adapt to environmental disturbances, guiding the bridge's structural design. Karl Terzaghi's Soil Mechanics Theory (1943) explains soil properties and bearing capacity, ensuring safe and stable foundations. In addition, the Structural Reliability Theory by P. Thoft-Christensen and M.J. Baker (1982) focuses on quantifying uncertainties in loads, materials, and environmental factors, ensuring that the probability of structural failure is minimized through the application of safety margins and design codes. Together, these theories ensure that the proposed short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan is resilient, stable, and reliable under both environmental and operational conditions.

Figure 2. *Theoretical Framework*

Conceptual Framework

INPUT	PROCESS	OUTPUT
1. What are the appropriate structural design parameters for the short-span bridge in terms of: a. Design load or load-bearing capacity (kN/m²), b. Recommended beam and slab dimensions (m), and c. Material specifications, including concrete compressive strength (MPa) and reinforcement grade? **2. How can the foundation be designed based on soil bearing capacity (kN/m²) to safely support the bridge loads?** **3. How can the proposed bridge design ensure safety, accessibility, and convenience for both vehicles and pedestrians, based on the perceptions and experiences of local residents?**	**Questionnaire Development for Community Respondents** **Structural Analysis and Design** STAAD.Pro simulation for load capacity, beam, and slab design; AutoCAD for 2D plans; SketchUp visualization for 3D structural model **Foundation Analysis and Design** Geotechnical computations for bearing capacity and sizing of footing/foundation type	**Drafted and Validated Survey Questionnaires for Community Respondents** **Optimized short-span bridge design in terms of:** a. Load capacity b. Beam and slab dimensions c. Material specification **Safe and stable foundation design in terms of:** a. Bearing capacity adequacy b. Appropriate foundation type for soil condition **Compliant bridge layout in terms of:** a. Conformity with DPWH standards b. Safety and accessibility for vehicles and pedestrians

Figure 3. *Conceptual Framework*

Statement of the Problem

This study aims to design a short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan, by focusing on its structural and foundation design. Specifically, this study aims to answer the following research questions:

1. What are the appropriate structural design parameters for the short-span bridge in terms of:
    a. Design load or load-bearing capacity (kN/m²),
    b. Recommended beam and slab dimensions (m), and
    c. Material specifications, including concrete compressive strength (MPa) and reinforcement grade?
2. How can the foundation be designed based on the soil bearing capacity (kN/m²) to support the bridge loads safely?
3. How can the proposed bridge design ensure safety, accessibility, and convenience for both vehicles and pedestrians, based on the perceptions and experiences of local residents?

Objectives of the Study

This study aims to design and evaluate a short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan, by focusing on its structural and foundation design in accordance with DPWH standards. Specifically, this research aims to:

1. Determine the appropriate structural design parameters of the short-span rural bridge in terms of load capacity, beam, slab, and truss dimensions, and material specifications.
2. Design the bridge foundation based on soil characteristics and allowable bearing capacity to ensure safe load support.
3. Assess the safety, accessibility, and convenience of the proposed bridge design for both vehicles and pedestrians, based on the insights and experiences of local residents.

Hypothesis

H_0: There is no significant difference between the proposed bridge design and the DPWH Bridge Design Manual standards in terms of structural safety and foundation stability.

H_1: There is a significant difference between the proposed bridge design and the DPWH Bridge Design Manual standards in terms of structural safety and foundation stability.

Significance of the Study

This study highlights the importance of safe and community-centered approaches in rural infrastructure development. By designing a structurally sound short-span bridge, the project aims to address not only engineering concerns but

also social and environmental impacts. Hence, this study seeks to benefit the following:

Public Transport Drivers. This study provides a safer and more reliable passage, reducing risks of accidents and vehicle damage, thereby ensuring an uninterrupted livelihood.

Community Residents. The bridge improves access to essential services such as markets, schools, health facilities, and workplaces, promoting connectivity and community development in Brgy. Poblacion and other rural areas.

Tourists and Local Economy. By enhancing access to natural attractions in Norzagaray, such as rivers, caves, and dams, this project supports tourism development and contributes to local business growth and economic opportunities.

Civil Engineers. This study contributes valuable insights into practical bridge design and construction methods, serving as a reference for future projects that aim to ensure structural reliability and public safety.

Emergency Responders. A durable and reliable bridge ensures safer and faster mobility for ambulances, fire trucks, and rescue teams, particularly during floods or dam water releases, thereby strengthening disaster preparedness and response.

Future Researchers. This study offers a foundation for further exploration in infrastructure projects, focusing on bridge design, foundation systems, and the application of sound engineering practices in rural settings.

Scope and Limitations of the Study

This study focuses on the structural and foundation design of a short-span rural bridge located in Brgy. Poblacion, Norzagaray, Bulacan. It specifically covers the determination of appropriate structural parameters, including load capacity, beam and slab dimensions, and material specifications, as well as the design of a safe and stable foundation based on local soil conditions. The study considers site-specific factors, available materials, and standard engineering practices to ensure a reliable and practical bridge design. Since this is an engineering-based study, it does not involve human respondents but instead relies on technical data, computations, and engineering standards. The study will be conducted within the academic year 2025–2026, and its findings aim to serve as a reference for future bridge design and planning in rural communities.

However, the study has certain limitations. It is limited to design and simulation using engineering software such as STAAD.Pro, SketchUp, and AutoCAD. It does not include full-scale construction, material testing, or field implementation of the bridge. The scope is also constrained by time, resources, and financial limitations, restricting the exploration of advanced construction

techniques. Therefore, the outputs are confined to design computations, drawings, and analyses, rather than physical testing or real-world performance evaluation.

Definition of Terms

To ensure clarity and avoid ambiguity, the following key terms are defined conceptually from authoritative sources and operationally as they are applied in the context of this study. These definitions provide a common understanding of the technical concepts used throughout the research.

Bearing Capacity Adequacy is the assessment of whether soil can safely support designed loads without settlement or failure (Das, 2016). In this study, it ensures the foundation is safe and stable.

Foundation Design is the process of determining the type, size, and depth of a foundation to safely transfer loads to the ground without failure (Bowles, 1997). In this study, it refers to footing selection and sizing based on soil capacity.

Hydraulic Forces are forces exerted by water flow, flood pressure, and debris impact on structures (Chow, 1959). In this study, it refers to flood-related forces acting on the bridge and foundation.

Load Capacity is the maximum amount of live and dead load that a bridge can safely carry (AASHTO, 2017). In this study, it refers to the allowable design load in kN/m^2.

Short-Span Bridge is a bridge with a span length of less than 20 meters, typically used to cross rivers, streams, or small gaps in rural areas (AASHTO, 2017). In this study, it refers to the bridge in Brgy. Poblacion, Norzagaray, Bulacan.

Soil Bearing Capacity is the maximum pressure the soil can support without shear failure or excessive settlement, expressed in kilonewtons per square meter (Terzaghi, 1943). In this study, it is determined if the soil can safely sustain bridge loads.

Standard Construction Techniques are the established engineering practices ensuring safety and quality in construction (DPWH, 2013). In this study, it refers to locally used techniques in rural bridge building.

Structural Design Parameters are the engineering specifications such as load capacity, beam and slab dimensions, and material properties that determine the bridge's ability to safely carry loads (NSCP, 2015). This study includes the compressive strength of concrete and reinforcement grade.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter is a section that analyzes and synthesizes existing knowledge on the study to support the objectives of the paper entirely. This review of literature and studies, conducted both locally and internationally, is organized by source type into foreign literature, local literature, foreign studies, and local studies.

Foreign Literature

Rural bridges are vital in connecting communities, ensuring access to schools, hospitals, markets, and workplaces. In many developing countries, the absence of reliable crossings forces residents to take unsafe routes or travel long detours. Thomas et al. (2021) found that in Rwanda, communities provided with small pedestrian bridges experienced measurable income growth, as residents could reach workplaces and markets more efficiently. Similarly, Mussah and van Overbeeke (2021) observed that rural trail bridges in East Africa encouraged the development of footpaths and complementary infrastructure. These cases demonstrate that even short-span bridges have significant social and functional impacts on community development.

Globally, bridge design is guided by established engineering codes to ensure safety, durability, and cost efficiency. Standards such as the American Association of State Highway and Transportation Officials (AASHTO) and Eurocodes provide specific guidance on short-span structures, including beam and slab dimensions, concrete strength, and reinforcement requirements. Devendiran et al. (2020) further highlight the importance of accounting for climate-related hazards such as flooding by incorporating appropriate design parameters. Drawing from these international standards enables this study to adopt suitable structural and foundation criteria for the short-span bridge in Norzagaray, Bulacan.

Research has also explored innovative materials and design concepts that enhance structural performance and extend service life. Pedneault (2021) analyzed short-span bridges in Canada that utilized aluminum composite decks and noted improvements in load capacity and resistance to environmental factors. Beudon et al. (2022) examined hybrid bridge systems using aluminum decks and timber beams, demonstrating high structural efficiency for short spans. While these materials are not yet common in the Philippines, such studies provide insight into potential design innovations that can improve bridge strength and reliability.

Climate adaptation has likewise become a critical consideration in modern bridge design. Tubaldi et al. (2022) noted that many bridges fail not primarily because of insufficient structural capacity but due to inadequate design against flood risks. Similarly, Habeeb and Bastidas-Arteaga (2023) analyzed climate

impacts on rural bridges and highlighted the need to consider hydrologic forces, soil conditions, and foundation stability in design computations. These studies underscore the importance of integrating environmental and geotechnical data into the design process to ensure overall safety.

Taken together, these international studies emphasize that short-span bridges are essential components of community connectivity and safety. For the proposed bridge in Brgy. Poblacion, Norzagaray, Bulacan, the lessons from global research highlight the importance of sound structural analysis, reliable foundation design, and adherence to established engineering codes to achieve a safe and resilient bridge structure.

Local Literature

In rural Philippine settings, stone masonry riverbank protection structures are commonly used due to the availability of local materials and their straightforward construction. However, these structures are particularly vulnerable to high-flow flood events. Since they are often built without proper foundation support, they become prone to settling and sliding due to local scouring at the toe of the bridge. To address these risks, the DPWH Bridge Repair Manual (2nd ed., 2020) recommends more resilient alternatives, such as concrete or wet masonry with pile-supported footings, particularly in flood-prone areas. In addition, the National Economic and Development Authority (NEDA, 2025) noted that ongoing

road and bridge improvements aim to enhance safety and accessibility for both vehicles and pedestrians.

Local case studies also emphasize the role of rural bridges in ensuring safety and accessibility. Patinio (2025) reported that residents of Barangay Kihan, Sarangani, were often cut off from essential facilities during heavy rainfall. The construction of a short-span steel bridge enabled them to travel safely and maintain access during emergencies. Likewise, Ocampo et al. (2023) found that prestressed concrete bridges can withstand greater loads and perform better under long-term service conditions than conventional reinforced concrete bridges, reinforcing their structural advantage for rural applications.

Bridge construction research in the Philippines highlights the importance of geotechnical evaluation in ensuring foundation stability. The DPWH Design Guidelines, Criteria, and Standards (2024) specify the need for soil and rock testing, including shear strength analysis, slope stability evaluation, and bearing capacity determination. Monitoring tools such as inclinometers and piezometers are used to detect ground movement, while laboratory tests, such as sieve analysis, hydrometer tests, Atterberg limits, specific gravity, consolidation, and unit weight determination, provide essential input data for design computations.

At the national level, the government recognizes the importance of strengthening rural bridges to support regional mobility and infrastructure resilience. The Department of Agriculture (2025) announced plans to construct

modular steel panel bridges in multiple provinces to enhance accessibility in remote areas. These initiatives underscore the continuing need for structurally sound and reliable bridge designs in local communities. Such efforts are consistent with the objectives of this study, which focuses on the structural and foundation design of a short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan, ensuring the safety and stability of a vital transport link for the community.

Foreign Studies

The materials used in bridge construction play a crucial role in ensuring structural performance and durability. Each material behaves differently under load, influencing strength, stiffness, and resistance to environmental factors. Fortin et al. (2023) examined the use of aluminum decks for short-span bridges and found that aluminum's high strength-to-weight ratio enhances load distribution and resistance to corrosion, making it suitable for areas exposed to moisture and flooding. Similarly, Lee et al. (2025) highlighted the increasing need to design bridges capable of withstanding climate-induced stresses such as extreme rainfall and temperature variations, emphasizing the integration of resilient materials to maintain long-term stability.

Material performance studies also provide insight into the structural behavior of concrete under varying conditions. Li et al. (2024) analyzed recycled concrete aggregate (RCA) and observed that higher substitution ratios can weaken

the interfacial transition zones (ITZ) and introduce microcracks. However, incorporating mineral admixtures such as silica fume and slag helps maintain compressive strength and improve ductility, offering potential for sustainable yet strong concrete mixes. Additionally, Zhang et al. (2023) reported that the compressive strength of concrete piles decreases with depth, with significant strength loss occurring in the upper and middle sections. This finding emphasizes the importance of proper foundation design and material testing for pile-supported bridge structures.

Advancements in bridge monitoring technologies also enhance the assessment of structural safety and performance. Rodriguez-Polania et al. (2025) introduced the use of Mesh-to-BIM technology, which provides detailed three-dimensional inspection data for short-span bridges. This method improves the accuracy of detecting structural defects, assists in evaluating load-bearing capacity, and supports the validation of design assumptions during bridge assessment.

Overall, these international studies underscore the importance of proper material selection, foundation integrity, and structural monitoring in achieving safe and durable short-span bridges. Their findings provide valuable guidance for the structural and foundation design of the proposed rural bridge in Brgy. Poblacion, Norzagaray, Bulacan.

Local Studies

In the Philippines, research and government initiatives highlight the need for resilient and well-designed bridges to improve rural accessibility and community safety. Panti et al. (2024) investigated the compressive strength of four local bamboo species and found that bamboo can achieve structural capacities comparable to timber. While not specific to bridge superstructures, their findings encourage further exploration of locally sourced materials that may complement traditional components in small-span bridge projects.

Community-based infrastructure studies also contribute to the technical and social understanding of bridge design. Julom et al. (2020) proposed a footbridge for Tierra Benita in San Jose del Monte, Bulacan, to address residents' challenges in river crossings. Their assessment of site conditions, materials, and community response underscores the importance of aligning technical feasibility with local context—a key consideration in designing a rural bridge in Brgy. Poblacion, Norzagaray.

Additionally, Bundi et al. (2024) and Adier et al. (2023) explored bamboo-based construction systems and treatment standards for structural applications in the Philippines. These studies demonstrate that with proper design and preservation methods, bamboo can be used as a secondary structural or non-load-bearing material, offering cost efficiency and sustainability for rural infrastructure.

At the national level, the Department of Public Works and Highways (DPWH) and the Department of Agriculture (DA) have emphasized rural bridge construction as part of national development. The DPWH's 2025 Feasibility Study for 25 Priority Bridges aims to enhance disaster resilience and regional mobility (DPWH, 2025; Marasigan, 2025), while the Farm-to-Market Bridges Development Program (FMBDP) launched by the DA (2025) allocates ₱27.7 billion for 300 modular steel panel bridges across the country. These initiatives demonstrate the growing recognition that short-span rural bridges play a vital role in promoting accessibility, safety, and local economic growth.

Collectively, these local studies and programs emphasize the importance of structural soundness, material suitability, and community-centered design. They serve as a foundation for the structural and foundation design of a short-span bridge in Brgy. Poblacion, Norzagaray, Bulacan, where a safe, durable, and context-appropriate structure is urgently needed following the failure of the existing bridge.

Synthesis of Related Literature and Studies

Rural bridges are essential for enhancing accessibility, mobility, and community development. International research shows that short-span bridges provide safer and more reliable routes, allowing residents to reach schools, markets, and essential services efficiently (Thomas et al., 2021; Mussah & van

Overbeeke, 2021). Studies on material performance such as aluminum decks, recycled aggregates, and low-carbon concrete emphasize how innovations improve durability and structural integrity while strengthening resilience against environmental stressors like flooding and soil erosion (Fortin et al., 2023; Santos et al., 2024). These findings highlight the importance of designing bridges that are structurally sound and adaptable to local site conditions.

In the Philippines, local research underscores the need for strong and durable bridge structures that meet community needs and environmental challenges. Ocampo et al. (2023) demonstrated that prestressed concrete offers superior load-bearing capacity and long-term reliability, while Julom et al. (2020) showed how bridge projects can directly address residents' safety and mobility issues. National initiatives from the DPWH and DA further support the development of short-span bridges to strengthen connectivity and resilience (DPWH, 2025; Marasigan, 2025). Together, these studies emphasize the importance of integrating proper structural and foundation design to ensure safety, stability, and serviceability, which are key considerations for the proposed short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter presents the methodologies used to conduct the study. It discusses the research design, population and sampling, research instruments, data-gathering procedure, and the statistical treatment used in the study.

Research Design

This study utilized a descriptive quantitative research design. It aimed to describe and analyze the existing bridge conditions in Brgy. Poblacion and determine appropriate structural and foundation design parameters for a short-span rural bridge.

The descriptive method was chosen because it focuses on collecting, analyzing, and interpreting factual data without experimentation. Quantitative techniques were applied to compute the structural and foundation parameters, ensuring objectivity and reliability of results. The study also included the perceptions of residents regarding the bridge's safety, accessibility, and usability for both vehicles and pedestrians.

Sample and Population

The respondents of this study were residents of Brgy. Poblacion, Norzagaray, Bulacan, specifically those who frequently use the bridge for travel, transport, or daily activities. They were considered the primary beneficiaries and end-users of the proposed bridge.

A purposive sampling technique was used to select participants based on their familiarity with and use of the bridge. The sample size consisted of 20 to 30 residents, ensuring diverse representation across different ages, occupations, and travel purposes.

Research Instrument

The study utilized a structured survey questionnaire and engineering tools to gather data necessary for designing a safe and accessible short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan.

Survey Questionnaire

A single validated survey questionnaire was developed for the community respondents (residents) who are regular users of the bridge. The instrument aimed to provide measurable data reflecting the community's perspective on how the existing bridge performs and what aspects need improvement for the proposed short-span rural bridge in Brgy. Poblacion, Norzagaray, Bulacan.

All items were measured using a 5-point Likert Scale, where respondents rated each statement from Strongly Agree (5) to Strongly Disagree (1). This format allowed the researchers to collect quantitative data that could be statistically analyzed to determine the bridge's current condition and its adequacy in meeting the safety and accessibility needs of both pedestrians and vehicles.

Point Value	Description	Rating Scale	Indicators
5	Strongly Agree	4.21-5.00	Fully Supports
4	Agree	3.41-4.20	Supports
3	Neutral	2.61-3.40	Neither
2	Disagree	1.81-2.60	Low Agreement
1	Strongly Disagree	1.00-1.80	Fully Disagrees

Table 1. Five-point Likert Scale for the Survey Questionnaire

Engineering Tools

1. STAAD.Pro for structural analysis, determining stresses, bending moments, and shear forces on bridge components.
2. SketchUp for 3D visualization of the bridge and conceptual alignment with the site.
3. AutoCAD for 2D design and layout drawings of the bridge.
4. Manual computation for foundation and soil analysis using formulas such as Terzaghi's bearing capacity equation:

$$q_a = cN_c + \gamma D_f N_q + 0.5B\gamma N_\gamma$$

where c is soil cohesion (kPa), γ is soil unit weight (kN/m^3), D_f is foundation depth (m), B is foundation width (m), and N_c, N_q, N_γ are bearing capacity factors based on soil type.

Data Gathering Procedure

The systematic process of gathering, analyzing, and interpreting data involved the following steps:

1. **Site Observation and Measurement**

The researchers conducted a field visit to document the existing bridge's dimensions, condition, and surroundings. Measurements of the bridge span, width, and river depth were recorded. Photos were taken before and after the recent repair works.

2. **Collection of Secondary Data**

Secondary data such as topographic maps (NAMRIA) and soil data (BSWM) were used to supplement field observations. Updates and documentation photos from social media and official sources were also referenced, properly credited to their respective owners.

3. **Survey Distribution**

The survey questionnaire was administered online through Google Forms to residents of Brgy. Poblacion, Norzagaray, Bulacan. This method ensured convenience and accessibility for respondents while allowing efficient collection of data regarding the bridge's current condition, safety, and accessibility.

4. **Data Processing and Structural Analysis**

Collected data were analyzed using STAAD.Pro for load and stress simulation, AutoCAD for drafting 2D plans, and SketchUp for 3D visualization.

Manual computations followed formulas from the DPWH Bridge Design Manual (2020) and NSCP (2015) to verify safety and stability.

5. **Validation and Documentation**

All collected responses and computations were tabulated and summarized for presentation in Chapter IV.

Statistical Treatment of Data

Data gathered from the residents were analyzed using descriptive quantitative methods. Demographic information such as age, length of residence, and frequency of bridge use was summarized using frequencies and percentages.

Responses from the Likert-scale questions were computed using the weighted mean to determine the overall perception of the respondents regarding the bridge's condition, safety, accessibility, and needed improvements. The weighted mean was computed using the formula:

$$Weighted\ Mean = \frac{\Sigma(f \cdot x)}{\Sigma f}$$

where f is the frequency of each response and x is the corresponding numerical value. Verbal interpretations were applied to the weighted means to show levels such as "Strongly Agree," "Agree," "Neutral," "Disagree," or "Strongly Disagree."

This statistical treatment provided a clear quantitative representation of the residents' perceptions, serving as the basis for assessing the safety and accessibility of the existing bridge and guiding the development of the proposed short-span rural bridge design.

SURVEY QUESTIONNAIRE

Greetings!

We are Civil Engineering students of La Concepcion College conducting a survey about our research study entitled, "***Structural and Foundation Design of a Short-Span Rural Bridge in Brgy. Poblacion, Norzagaray, Bulacan***." This survey is intended for the residents of Brgy. Poblacion, Norzagaray, Bulacan, who are familiar with and frequently use the existing bridge.

The purpose of this study is to determine the appropriate structural and foundation design for a proposed short-span rural bridge in your community. Your responses will help us understand the bridge's current condition, its safety, accessibility, and the improvements needed to ensure the design is both safe and functional for vehicles and pedestrians.

By agreeing to participate, you are giving your voluntary consent to be part of this research in accordance with the Data Privacy Act of 2012. All responses will be kept strictly confidential and used only for academic purposes.

We would greatly appreciate a few minutes of your time to complete this questionnaire. Thank you for your cooperation, and God bless you!

Demographic Profile
Instruction: Please fill in the blanks or select the appropriate answer.

Name (Optional): _____ Age: _____
Length of residence in Brgy. Poblacion:
- ▢ Less than 1 year
- ▢ 1-5 years
- ▢ 6-10 years
- ▢ More than 10 years

Frequency of bridge use:
- ▢ Daily
- ▢ Several times a week
- ▢ Occasionally

Mode of use:
- ▢ Walking
- ▢ Motorcycle
- ▢ Tricycle
- ▢ Car
- ▢ Others: _____

Instruction: For each of the following statements, please indicate your level of agreement by placing a check mark (✔) on the box that best describes your opinion or experience. There are no right or wrong answers. Your honest responses are important to ensure the accuracy of this study.

Scale:

5 - Strongly Agree (Lubos akong sumasang-ayon)
4 - Agree (Sumasang-ayon ako)
3 - Neutral (Katamtaman ang pagsang-ayon ko)
2 - Disagree (Hindi ako sumasang-ayon)
1 - Strongly Disagree (Lubos akong hindi sumasang-ayon)

I. Current Bridge Condition

Statement	**5**	**4**	**3**	**2**	**1**
1. The existing bridge feels stable and safe to use.					
2. The bridge remains safe to use during heavy rain or flooding.					
3. The bridge can handle both people and vehicles at the same time.					
4. The bridge shows signs of damage, such as cracks or uneven parts.					
5. The bridge is wide enough for vehicles to pass safely.					
6. The bridge railings or side barriers are strong and secure.					
7. The area surrounding the bridge is clean and free from flooding.					
8. The lighting and visibility around the bridge are sufficient for night use.					

II. Safety and Accessibility

Statement	5	4	3	2	1
1. I feel safe when walking or driving on the bridge.					
2. The bridge does not shake or feel unstable when vehicles pass by.					
3. The bridge has enough space for both people and vehicles to pass safely.					
4. The bridge can be easily used by everyone, including elderly or disabled residents.					
5. The bridge can still be used safely during floods or has another safe route nearby.					
6. The bridge floor is not slippery and feels safe to walk on.					
7. The bridge feels strong even when many people or vehicles are using it.					
8. The bridge is wide enough for vehicles to go both ways safely.					

CERTIFICATE OF VALIDATION

This is to certify that the following students **Sharee Maine Mostrales, Cielo Marie Pearl M. Guieb,** and **John David V. Almadin**, with the research study entitled, ***"Structural and Foundation Design of a Short-Span Rural Bridge in Brgy. Poblacion, Norzagaray, Bulacan,"*** have submitted their research instrument for validation. The questionnaire has been reviewed and evaluated by the undersigned validators in terms of content, clarity, and relevance to the study's objectives.

After thorough evaluation, the instrument was found to be valid, appropriate, and acceptable for data gathering purposes.

Validated this 27th day of October, 2025, at La Concepcion College, City of SJDM, Bulacan.

Validated by:

Engr. JORE GIL GALEZA, Ph.D.
Division Head of Civil Engineering
La Concepcion College

Engr. ELOISA P. CADAG, REG. CE., MACT
Research Adviser, Civil Engineering Division
La Concepcion College

Engr. RUSSELL R. LLAGAS, REG. CE.
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